Heritability of entropion in several US sheep breeds

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Abstract

Heritability for incidence of entropion was estimated in an experimental flock of purebred (Columbia (C), Polypay (P), Rambouillet (R), Suffolk (S), and Targhee (T)) and crossbred (from matings of Finnsheep rams with C, R and T ewes, from Merino × R matings, and from miscellaneous other matings) lambs. Data from 1986 to 1994 which included 39 440 records were analyzed using a multiple trait REML program with an Animal Model (AM). Overall mean incidence rate for entropion was 3.1% over a 9 year period, ranging from 1.1% in 1988 to 5.0% in 1989. Breed group ranking within each year was consistent, with overall mean incidence rates of 10.4%, 6.9%, 6.4%, 3.7%, and 3.3% for Suffolk, Merino-crosses, Columbia, Targhee, and Rambouillet groups, respectively. Purebred Polypay and Finn-crossbred lambs each had 1.0% overall incidence rate. For all breed groups analyzed together, the direct heritability estimate for incidence of entropion was 0.15. Heritability estimates for separate purebred groups were 0.21, 0.17, 0.10, 0.09 and 0.08 for C, S, T, R and P, respectively. It was concluded that selection against entropion can lower incidence rates, at least in Columbia and Suffolk breeds.

Keywords: entropion; sheep; heritability; genetic parameters

1. Introduction

Entropion is inversion of the eyelid and associated lashes or external hair in one or both eyes. This, frequently bilateral, condition is a congenital defect affecting both sexes of lambs (Joyce, 1981). Incidence rates can vary substantially among breeds. Warwick and Berry (1962) reported 3.7% incidence rate in an experimental flock, whereas Warwick (1931) recorded 25% in a mixed flock. McManus (1960) found incidence rates as high as 80% in a flock in Tasmania. Most reports characterize this condition as hereditary, yet there is no consensus on the mode of inheritance. Ellis (1943) recorded entro-

pion in Oxford Downs in the UK, and suggested that it was a hereditary condition transmitted by the sire. Wright and Formston (1943) reported annual incidence rates of 3.4–22% in crossbred lambs sired by Hampshire Down rams, depending on source of rams. Taylor and Catchpole (1986) suggested that the condition can be transmitted to progeny by either parent. In a survey conducted in over 100 flocks in Scotland, Littlejohn (1954) found occurrence of entropion in more than half of the flocks, and indicated that although the condition was hereditary, it was not inherited as a simple Mendelian recessive gene. Crowley and McGloughlin (1963) discussed dominant and recessive inheritance and concluded that partial dominance could not be overlooked as a possible mode of action. In more recent literature, entropion is reported as a highly heritable complex trait which can be aggravated by environmental con-

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Table 1
Number of entropic/normal lambs by breed group and year

Breed group	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Columbia	62/625	40/641	39/759	47/588	40/699	45/711	49/832	18/275	26/627	366/5757 (6.4%)
Polypay	6/521	1/550	1/704	25/1057	12/1133	9/1356	7/1013	5/452	6/594	72/7380 (1.0%)
Rambouillet	16/791	10/817	5/810	44/671	4/186	34/832	34/1005	15/465	56/942	218/6519 (3.3%)
Suffolk	–	–	1/72	7/75	10/106	10/111	24/129	9/99	13/121	74/713 (10.4%)
Targhee	28/856	16/872	14/895	42/639	42/700	41/748	45/1095	8/362	9/461	245/6628 (3.7%)
Finn-crosses [a]	20/1881	9/1921	5/2097	4/115	6/293	6/255	11/345	–	–	61/6907 (1.0%)
Merino-crosses [b]	–	–	–	–	20/285	–	2/32	–	–	22/317 (6.9%)
Misc [c]	11/261	6/375	0/344	25/769	27/994	9/642	27/536	35/825	10/473	150/5219 (2.9%)
Total	143/4935	82/5176	65/5681	194/3914	161/4396	154/4655	199/4987	90/2478	120/3218	1208/39440
	(2.9%)	(1.6%)	(1.1%)	(5.0%)	(3.7%)	(3.3%)	(4.0%)	(3.6%)	(3.7%)	(3.1%)

[a] Finn-crosses include lambs from matings of Finnsheep rams with Columbia, Rambouillet and Targhee ewes.

[b] Merino-crosses include lambs produced by AI of Rambouillet ewes using semen from Finewool and Strongwool Merino rams.

[c] Miscellaneous other crossbred genotypes combined.

ditions (SID, 1988). The objective of this study was to determine the magnitude of direct heritability for occurrence of entropion.

2. Materials and methods

Data were collected from purebred and crossbred lambs born in the US Sheep Experiment Station research flock from 1986 to 1994 (Table 1). Pure breeds included were Columbia, Polypay, Rambouillet, Suffolk and Targhee. Crossbred lambs were (1) from matings of purebred and crossbred (F_1) Finnsheep rams with Columbia, Rambouillet and Targhee ewes, (2) Merino $\times$ Rambouillet F_1 crosses produced by AI using semen from Finewool and Strongwool Merino rams on Rambouillet ewes, and (3) from various other crossbreeding (involving F_1, F_2 and backcrosses) schemes pooled as a separate group (labeled as Misc) for analysis. No direct selection was practised against entropion in this flock before 1990. However, between 1990 and 1994, rams that exhibited entropion as lambs were excluded from matings whereas entropion history of the ewes was not given any consideration. Entropion status was recorded as entropic or normal within 6–24 h after birth.

Estimation of genetic and phenotypic parameters was carried out using an animal model and derivative-free REML software (MTDFREML; Boldman et al., 1993). Two separate analyses were carried out. In Analysis 1, all breed groups were analyzed together to obtain parameter estimates for the whole flock. The statistical model included year and breed group as fixed effects. The data file contained entropion records for 39 440 animals. The pedigree file covered the period from 1961 to 1994, and the relationship matrix (A^{-1}) included 48 555 animals. In Analysis 2, Columbia, Polypay, Rambouillet, Suffolk and Targhee data were each analyzed separately to obtain breed-specific parameter estimates. When a crossbred group was composed of at least 75% by one of the purebred groups, then those records were included with purebred data for this analysis. A total of 3587 records were added to the purebred data by this procedure. Size of data and pedigree files, respectively, were 6859 and 8855 for Columbia, 7214 and 8274 for Polypay, 7726 and 10 573 for Rambouillet, 713 and 808 for Suffolk, and 8072 and 10 929 for Targhee breeds. The statistical model for each breed included year as a fixed effect. Models for both analyses also included random animal genetic effects. The statistical program was started several times with varying prior estimates to insure global maximization of the likelihood. Number of sires per breed ranged from 21 (Suffolk) to 206 (Targhee), and overall average numbers of progeny per sire ranged from 28.1 (Suffolk) to 47.8 (Polypay; Table 2).

3. Results and discussion

Overall incidence rate for entropion was 3.1% over 9 years (Table 1). Incidence of entropion varied ($P < 0.0001$) among years, ranging from 1.1% in 1988 to 5.0% in 1989. Likewise, between-breed variation was highly significant ($P < 0.0001$) for percentage of lambs with entropic eyelids, with Suffolk lambs highest (mean occurrence of 10.4%) and Polypay lambs lowest (1.0%). There was a reasonable consistency in breed rankings within years: Suffolk lambs had the highest rates of entropion occurrence in 6 of the 7 years they were in the flock

Table 2
Number of sires and mean progeny numbers per sire by entropion status and purebred group

Breed	Entropic progenies		Normal progenies		Overall	
	Sires	Lambs	Sires	Lambs	Sires	Lambs
Columbia	97	3.9	150	42.5	150	45.0
Polypay	40	1.8	151	47.3	151	47.8
Rambouillet	79	2.7	168	39.3	168	40.6
Suffolk	12	5.1	21	25.2	21	28.1
Targhee	89	2.2	206	32.5	206	33.4

and Polypays were lowest in nearly every year. Overall rate of entropic eyelids in Columbia lambs (6.4%) was about twice that of Rambouillet (3.3%) and Targhee (3.7%) lambs.

Estimates of additive genetic and total phenotypic variances for occurrence of entropion, all breeds combined, were 0.0043 and 0.029, respectively, resulting in a heritability estimate of 0.15. To avoid possible biases in parameter estimates owing to missing observations in some years for Merino-crosses and Suffolk groups, the same model was rerun after these two groups were combined with the 'Misc' group. This did not change the estimated heritability value.

The second set of analyses, where each breed was analyzed separately, resulted in direct heritability estimates of 0.21, 0.17, 0.10, 0.09 and 0.08 for Columbia, Suffolk, Targhee, Rambouillet and Polypay breeds, respectively. The breed ranking for overall observed rate of entropion occurrence, from highest to lowest, was Suffolk, Columbia, Targhee, Rambouillet, and Polypay. The ranking based on heritability estimates was similar, with the exception of Columbia having the highest heritability.

Selection of rams has been recommended by several workers as a means of reducing incidence rates of entropion in progeny (e.g. Leipold, 1984). In a UK flock, incidence rate of entropion was reported to be reduced from 22% in 1940 to 3.4% in 1943 through selection of rams (Formston, 1991). For most years in our flock, a high proportion of lambs with entropic eyelids were progeny of only a small number of sires in each breed. For example, two Suffolk rams sired 63% and 33%, respectively, of all entropic lambs in that breed in 1992. Similarly, all of the nine entropic Suffolk lambs in 1993 were progeny of the same ram. Sample size for Suffolk breed was not large enough to draw firm conclusions from this trend regarding possible small number of genes involved in determination of entropion occurrence. In the other breeds, 40–70% of all entropic lambs in each year were sired by only a small number of sires. Therefore, a careful review of pedigree records is essential to insure that rams selected to sire the next generation are free of entropion. This has been the practice in our flock since 1990. The question of whether a small number of genes may be affecting this trait is an interesting one which would require an experiment designed specifically to determine the mode of inheritance of entropion. In conclusion, the magnitude of the estimates of heritability reported here suggests that selection can successfully lower occurrence rates of entropion, at least for Columbia and Suffolk breeds. However, given the relatively low heritability values for these breeds, it would take several generations to achieve the selection objectives.

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